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Space Supporting Sustainable Development in Africa: Views from the Continent

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Abstract

Nowhere on Earth are the societal benefits of space technologies more urgently needed than in Africa. For this reason, the continent has, in recent years, strongly pursued and promoted space technologies and applications, as evidenced by the African Space Policy and Strategy (ASPS) and the African Space Agency (AfSA). The European Space Policy Institute (ESPI), supported by the European Space Agency (ESA), is on the forefront of researching the latest developments in Africa, specifically in line with AfSA's mission of exploiting space technologies and applications for sustainable development and the improvement of the welfare of African citizens. The "Space2030" agenda cannot succeed without Africa, and this recognition is reflected in its calls for bridging the space divide. The starting point in such an endeavour must necessarily be to identify the needs on the ground and to understand and seek ways to support Africa's home-grown initiatives for meeting its challenges, in line with the United Nations Sustainable Development Goals (SDGs). The age of Africa's full participation and partnership in space is dawning with the birth of AfSA. ESPI's approach in this study is to identify linchpin or primary needs within the Sustainable Development domain on which Africa's pursuit and promotion of space technologies and applications rely most of all. These are climate, biodiversity, health, water, education, and space-related capacity building. Promoting African success in harnessing space to support these areas, including via partnership with ESA, requires an understanding of the African international space ecosystem. This means understanding the continent's own Sustainable Development goals and strategies, as encapsulated in Agenda 2063, its existing intra-African space partnerships as well as African participation and partnerships in space globally, and its policies and space applications already in use. It also requires identifying African space growth poles in a socioeconomic landscape characterised by the abovementioned primary needs. This must also be supplemented by an understanding and appreciation of uniquely African worldviews such as *ubuntu* and the Pan-African solidarity norm. This provides a rich contribution to International Relations scholarship and provides novel approaches to engaging with the collectivist African posture of seeking solutions in the space arena in a spirit of partnership and unity. Ultimately, engaging with Africa and its rising space nations not only benefits the continent but through concepts such as emerging space middle powers it becomes clear how this helps in legitimising the global space regime, of which "Space2030" is a crucial part.

Keywords: Africa; Sustainable Development Goals; Outer Space; Agenda 2063; Primary Needs; New Actors in Space

1. Introduction

This manuscript reports on the first part of an ongoing, overarching study on the ways in which space supports Africa's development goals [1]. For many observers, the image of Africa as a rising space actor is a surprising and often unexpected one, given the serious socio-economic and political challenges with which the continent is grappling. Nevertheless, today all of the continent's 54 states are participating in the space sector by making use of space-related or space-derived data in some form, while many are participating in a variety of Intergovernmental and Non-Governmental Organisations and fora focusing on space (such as the United Nations Committee on the Peaceful Uses of Outer Space, UNCOPUOS) with some African states becoming rising space actors in their own right by establishing national space agencies and owning (and in some cases even building) satellites.

As African countries are working towards meeting the United Nations Sustainable Development Goals (SDGs) 2030 and the African Union's Agenda 2063, the need to explore the role of space applications in supporting these efforts is urgent. In this first instalment of the study on space supporting Africa, the background

and context of Africa's political and socio-economic landscape is presented and unpacked through a primary needs approach which focuses on climate, biodiversity, health, water, education, and space-related capacity building. African theoretical contributions from the International Relations field are discussed, and Africa's new Space Policy and Strategy (ASPS), along with debates around the establishment of the African Space Agency (AfSA), are explored. The African International Space Ecosystem is analysed, including its dimensions of intra-African space relations and initiatives, African participation in UNCOPUOS, and international space activities, agreements, and initiatives in Africa. The final part is dedicated to the national space infrastructure and activities of African states. This lays the foundation for the subsequent instalments in the overarching study. This manuscript will present some of the findings, first contextualised by an overview of the continent and its major political and economic trends and challenges.

1.1 Africa and the space arena: overview

In order to take stock of Africa's progress in the space arena, and to determine how far advanced the space sector is across the continent, the study examined the continent's political background and context, with particular emphasis on the African Union and the Regional Economic Communities (RECs) that make up its key organs. This was then followed by an investigation of the general socioeconomic situation (including the African economy and promise of the 'digital renaissance') within a framework of the primary needs approach to African space activities (see below). These identify priority areas of critical importance, which must be supported by space if it is to make a meaningful contribution to Africa's development and the lives of ordinary Africans. Alongside this, concepts of *ubuntu* (a uniquely African worldview) and emerging space middle powers are utilised as novel frameworks to be drawn on. Throughout, focus is placed on the African Union's Agenda 2063 as the core policy document on a continental level that will guide Africa towards a sustainable development future, in line with the SDGs. Methods used for ranking African space capabilities were reviewed, as was the background of African space activities up to the end of the twentieth century. A review was also performed of the African Space Policy and Strategy that frames Africa's 'Astronaissance' [2], followed by an analysis of debates around the establishment of the African Space Agency.

1.1.1 Africa's political organisation

The AU is the most politically important organisation on the continent, with all 54 sovereign African states as members, in addition to the Sahrawi Arab Democratic Republic. Its vision is to create "[a]n integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena" [3]. The AU can be subdivided into eight intergovernmental organisations — the RECs — that constitute the 'building blocks' of the union, having been proposed as a mechanism for regional and continental African integration, through the Lagos Plan of Action for the Economic Development of Africa (1980) and the Abuja Treaty (1991) [4]. All 54 countries are members of at least one REC, with some having membership in more than one.

These RECs predate the creation of the AU itself, and have somewhat different structures and roles, while their broad mandate of fostering regional economic integration has evolved to include coordination in wider areas such as governance, development, and security. The RECs are thus key organs of the AU. They are the Arab Maghreb Union (UMA), the Common Market for Eastern and Southern Africa (COMESA), the Community of Sahel-Saharan States (CEN-SAD), the East African Community (EAC), the Economic Community of Central African States (ECCAS), the Economic Community of West African States (ECOWAS), the Intergovernmental Authority on Development (IGAD), and the Southern African Development Community (SADC).

This study made use of the RECs in its analysis of African space activities and policies, for the reason that there have been calls for building an African Regional Space Regime Complex from these RECs. It has also been argued that each of the RECs has at least one national space agency, and since they are in effect the "implementing arm of the African Union" and the building blocks of its economic integration, building a broader continental "appetite" for space collaboration and integration through the RECs is thus a sensible idea [5]. Thus, the analysis of space-related capabilities, activities, and infrastructure followed a structure based on the RECs.

1.1.2 Political challenges

In order to provide the foundation and context for the analysis of the African space ecosystem, the study considered aspects of political challenges, since these are critical factors framing the role of space in Africa. These can only be mentioned here, but in-depth analysis is presented in the larger study [1]. Laudable progress in democratisation and governance is being made across Africa, but many political challenges still confront African countries and threaten socio-economic development and progress in sectors, including space. Many countries are still politically fragile, while corruption remains a serious challenge. Political rights and civil liberties (including electoral processes, political pluralism and participation, the functioning of government, issues of expression and belief, personal autonomy and individual rights, associational and organisational rights) and the rule of law pose numerous

challenges and on many of these fronts Africa performs poorly. Peace and security is another political arena where many challenges remain. In recent times, Africa has also grappled with several major refugee and migration crises, including major internal displacements, while discrimination and marginalisation is also rampant, especially for women and girls, people with albinism, and lesbian, gay, bisexual, transgender, and intersex people.

The political challenges in Africa thus remain significant. However, a key realisation is that Africa has not remained passive in the face of these challenges. One of the core concepts used as both an expression of Africa's hope for the future and a driver of change is that of the African Renaissance. Its aim is a "golden age of Africa's social economic and political institution building through good governance and improved state-society relations" [6]. The African Renaissance became the vision to inspire, and create fertile ground for, the rebirth of the continent.

Agenda 2063 is the core policy document on a continental level that will guide Africa towards a sustainable development future, in line with the SDGs. At its core, Agenda 2063 is a strategic framework that builds on and accelerates previous and current initiatives to achieve sustainable development and economic growth and lays the foundation for the socio-economic transformation of Africa over a 50-year period. Agenda 2063 furthermore identifies 12 key flagship projects for the continent, one of which is the Africa Outer Space Strategy. The aim of this flagship programme is to strengthen the use of outer space to support and reinforce Africa's development. It encapsulates the recognition that African development is critically dependent on outer space and space technology. Moreover, it contends that the products of space technology are "no longer a matter of luxury" and access to space technology and products must be sped up [7]. It also recognises that satellite technology is more accessible than ever to African countries. The Agenda 2063 framework was incorporated throughout the study since all development, including in the space sector, must speak to Africa's own developmental goals.

1.1.3 Socio-economic overview

To further contextualise the African space sector, an in-depth analysis was conducted on the broad socio-economic state of affairs on the continent. This included the main challenges confronting Africa, since the use of space technology in Africa must speak to these challenges in order to be viewed as valuable and successful.

Dimensions analysed included gross national income per capita, human development, Gini coefficient (inequality), percentage of population living on less than $1.90 a day (at 2011 international prices), dominant sectors driving African economies, largest employment sectors, leading contributing sectors to GDP, economic complexity, annual GDP growth rates, business environment, and global competitiveness. Special focus was placed on information and communications technologies which have revolutionised the African economic landscape, especially smartphones, and the broader African digital revolution and its related challenges.

2. Theoretical frameworks and contributions

Two important concepts were used throughout the study both as theoretical frameworks and contributions to the space literature, namely *ubuntu* and emerging space middle powers. This is a novel endeavour since *ubuntu*, as a unique African worldview and international relations perspective, has never been coupled with the space arena. The emerging space middle powers concept, along with *ubuntu*, helps to further an understanding of how Africa's regional powers fit into the global system and to give explanations to their behaviour and actions, particularly on continental level. This is useful since African space initiatives are largely driven by regional powers (also explaining the core focus on the RECs).

There has been a recent effort in the field of IR theory to seek non-Western, including African, concepts to enrich a discipline that is still primarily dominated by work from the United States and Europe [8]. One such concept is *ubuntu*, which reinforces the notion of Smith [8] that Africa has always possessed agency in world system and has not simply been "acted upon" by others. This agency has been clarified by arguing that its uniqueness "lies in its qualification 'African' which is both self and place bound" and the role of Afrocentricity within this agency is critical in the sense that "Afrocentricity emerges as a methodology that consciously operates within African ways of knowing and existence and results in the implementation of principles, methods, concepts and ideas that are derived from our own African cultural experiences" [9]. However, no attempt has been made to bring such unique African insights into the outer space literature, and even in the International Relations theory field it is a new development. The first concept here, *ubuntu* has been argued to be an indigenous worldview, and although the word itself originates from Southern Africa, specifically the Nguni language family, manifestations of *ubuntu* can be found across Africa, legitimising it as an African view of the international [8]. The term *ubuntu* is encapsulated in the well-known isiXhosa proverb *Ubuntu ungamntu ngabanye abantu*, which means "people are people through other people" [8]. Its value in IR, and thus space literature, is that it puts forth an alternative collectivist understanding in contrast to the Western individualist ontology [10]. *Ubuntu* is a valuable tool in IR since it can explain behaviour among African states, and helps to shed light on the pan-African solidarity norm, for

example, as well as the reasoning behind Africa's preferred form of international engagement, namely multilateralism.

The second concept incorporated is that of emerging middle powers. The middle power literature is well-established in IR, but an important adjustment was made by a South African scholar to distinguish between traditional and emerging middle powers [11]. By unpacking this concept of emerging middle powers, it can be adapted into a framework allowing the identification of several emerging 'space middle powers' in Africa that uphold the international order in space. This concept of emerging space middle powers also contains an important distinction from that of more traditional regional powers. The features of regional powers are summarised as states that conceive of themselves as leaders in their region, possess power projection capabilities, influence regional affairs, influence the 'political-ideational construction' of their region, use their influence in regional governance structures, strongly influence the regional security agenda, present a common regional identity or project, provide or assist in providing a collective good for the region, are recognised globally for their regional leadership, and represent their regions in global fora. If the active participation of all (or most) African states in the space arena is to be achieved, the role of the emerging space middle powers in legitimising the governance structures and 'status quo' (treaties, etc.) in the space arena is crucial. These emerging space middle powers must be the bridge between Africa and outer space.

These two concepts – *ubuntu* and emerging space middle powers – are incorporated throughout the study. The next section will reflect on the models created to aid the analysis of the African international space ecosystem.

3. Models

Throughout our study, models were created and used to guide and frame each of the major sections. These models are summarised here. The first of these is the primary needs approach to African space activities model (Fig. 1.). As space and space-related products and services are now more deeply integrated into daily life than ever, their impacts on those priority areas that are of critical importance for improving human development and welfare in Africa are placed at the centre of our study.

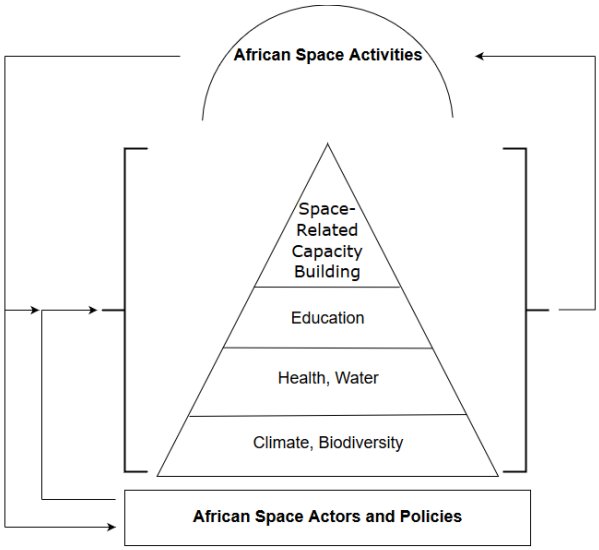

Fig. 1. Primary needs approach to African space activities model

All human activity and welfare depend powerfully on the climate and on biodiversity, and these areas are thus placed at the foundation of the model. They directly feed into health and water. Education, without which no lasting, genuine progress can be made in the space sector or any other, is also here regarded as a primary need, since it empowers people to transform society in line with the SDGs. This then feeds into space-related capacity building, which, in its turn, is a primary need for the African space sector to take off and address the socio-economic development needs of the continent. All these factors then directly feed into Africa's space activities and infrastructure. These then filter back into the areas of climate, biodiversity, health, water, education, and space-related capacity building since space activities, services, and technologies are used to support these.

An important note here is that these primary needs are all closely linked to the SDGs. Climate is linked to SDG 13 ("Take urgent action to combat climate change and its impacts"), biodiversity is linked to SDG 14 ("Conserve and sustainably use the oceans, seas and marine resources for sustainable development") and SDG 15 ("Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"), health is linked to SDG 3 ("Ensure healthy lives and promote well-being for all at all ages"), water is linked to SDG 6 ("Ensure availability and sustainable management of water and sanitation for all"), education is linked to SDG 4 ("Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all"), and space-related capacity building is arguably linked to SDG 9 ("Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation") [12].

The second model was used to analyse the African international space ecosystem (Fig. 2.).

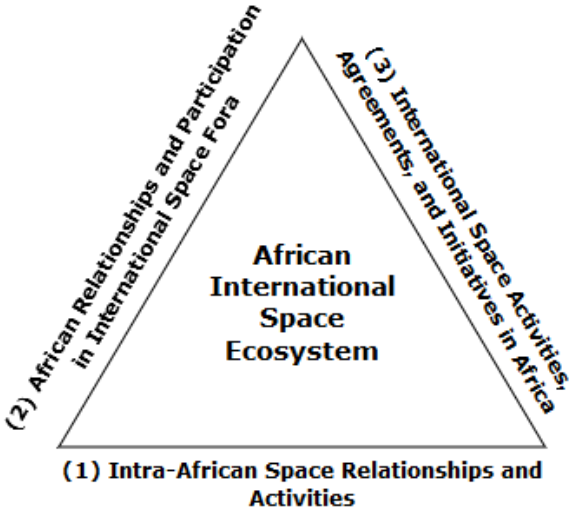

Fig. 2. African international space ecosystem model

This international ecosystem is conceptualised as consisting of three dimensions. The first of these dimensions concerns intra-African space relations and activities taking place between various countries on the continent. The second dimension revolves around African relations and participation in international fora, with emphasis on UNCOPUOS. The third dimension is concerned with the involvement of international space actors on the African continent, as well as various other international agreements and initiatives.

In terms of intra-African space relations and activities, the analysis included the discussion of various continental projects taking place such as the African Resource Management Satellite Constellation (ARMS-C), the Square Kilometre Array (SKA), and others. These were analysed through the Intra-African Space Engagement (IASE) Matrix, a tool that helps to identify emerging space middle power candidates via the regional dimensions of the middle powers concept (see theoretical framework below). Here, a matrix is understood as the cultural, social, or political environment 'substrate', in this case, specifically for the use of space to meet primary needs in Africa. The environment in this case is made up of the various IGOs and NGOs discussed in depth in the study, which all serve individually as vehicles for developing the use of space and collectively as a web or network of African space-related organisations, relationships, and activities.

The next step is to explicate the methodology used in the creation of the IASE Matrix. While all of these organisations play critical roles in promoting space technologies, data, or skills, for the purpose of producing the IASE Matrix, two points were assigned to each African country for membership in an IGO or for hosting the activities or conferences of an IGO, whereas involvement in the NGOs were assigned one point. The reason for this distinction is because when a state joins an organisation, it signifies greater national involvement in promoting space activities than when their citizens found or join a space-related NGO. The aim was thus to provide a general indication of which countries are more active players in intra-African space affairs and thus to create an image of patterns of intra-African relations and activities. The IASE Matrix thus simplifies a very complex field in order to facilitate comparison. Moreover, while countries received a score for participating in an organisation or project, they received an additional point if they were a host nation. This is because "experience with African continental organisations has shown that the host country winds up shouldering the lion's share of the financial burden of sustaining such entities" [13]. The findings of the IASE Matrix will be presented in the next section.

The second dimension of the African international space ecosystem is that of involvement in international space fora, most notably UNCOPUOS. This was in turn analysed through the International Space Engagement (ISE) Matrix, which identified emerging space middle power candidates based on the international dimensions of the concept. Together, the IASE and ISE Matrices identified Africa's emerging space middle powers and help to account for their actions, along with *ubuntu*, within the international space ecosystem. The ISE Matrix considers whether states are members of UNCOPUOS or have assumed leadership positions within the main or subcommittees, whether they are active members of UNCOPUOS, whether the core outer space treaties have been ratified, and to gauge African engagement in the broader United Nations Office for Outer Space Affairs (UNOOSA) architecture. Other factors were also considered including: participation and hosting of regional offices of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), appointing of a National Focal Point as requested by UN-SPIDER of all member states, and hosting of a Regional Centre for Space Science and Technology Education. This helps to provide a more complete picture of African engagement with UNCOPUOS and UNOOSA. All of these factors were combined to create the ISE Matrix. To make the ISE Matrix meaningful, higher scores were assigned for greater engagement. Thus, scores are assigned as follows: signing a treaty, 1 point; ratifying a treaty, 2 points; being an UNCOPUOS member, 3 points; being an active participant (attending more than half of all sessions from 2015 to 2018), 4 points; chairing any committee, 4 points; participating in UNOOSA's African institutions (UN-SPIDER National Focal Point), 3 points; and hosting one of these institutions (UN-SPIDER Regional Office or Regional Centre for Space

Science and Technology Education), 4 points. The findings of the ISE Matrix are also presented in section 4. As with the IASE Matrix, it is possible to identify the 'outliers' in international space engagement based on the ISE score assigned to each country.

A third model used in this study presents the interlinked nature of the analysis, and focused on identifying African space growth poles (Fig. 3. – see end of document). This incorporated aspects of Africa's relations in the space arena and participation and engagement on the continent and beyond, capabilities of African states with regard to space-related infrastructure and national space activities, and frameworks used in the analysis of these activities, grounded in the socio-economic landscape of Africa (and primary needs in particular).

In relation to the frameworks employed, these are drawn from the relevant literature, which presents a variety of frameworks to facilitate analysis of national space capabilities. The first approach, taken by Wood and Weigel [14], uses a Space Technology Ladder to provide a framework to chart the path countries have taken in terms of their technological capacity in space technology. Wood and Weigel's Space Technology Ladder is also useful since it allows for the creation of a graphical timeline, comparing the achievements of various African countries (see the next section for findings in terms of this study). The Space Technology Ladder was modified in line with six main shortcomings found in related literature, and the modified version that includes 16 milestones is presented in Table 1.

Table 1. Modified Space Technology Ladder

4. Launch Capability	16. Astronaut to space
	15. Satellite to GEO
	14. Satellite to LEO
3. MEO/GEO Satellite	13. Build locally
	12. Build through mutual international collaboration
	11. Build locally with outside assistance
	10. Procure
2. LEO Satellite	9. Build locally
	8. Build through mutual international collaboration
	7. Build locally with outside assistance
	6. Build with support in partner's facility
	5. Procure with training services
1. Establishing Space Policy, Agency and Infrastructure	4. Establish space AIT centre/space industry
	3. Establish current national space agency [critical factor for High/Medium/Low Space Technology Countries]
	2. Establish first government space office
	1. Establish first government space policy

The second framework used was created by Harding [15] and provides a larger picture that identifies two main groups of countries. The first group is the category of developed space actors (DVSAs). The second group is that of emerging space actors (EMSAs), and was of main interest in this study. This category is itself further subdivided into three tiers. The first-tier EMSAs are the largest and most capable states within their group and are China, India, and Brazil. More important for this study are the second- and third-tier EMSAs, which Harding describes as "smaller but no less enthusiastic states [that] now make up the majority of the world's space actors" [15]. A point that has to be underscored is that it "has become apparent . . . that a nation does not need to have a satellite in space to be space capable", for example, "[s]everal countries are space capable, are avid users of Earth observation data, and do not yet have any specific space-based assets of their own" [16].

The third framework that adds more detail than the Space Technology Ladder is the European Space Agency's Technology Readiness Level (TRL). Although this TRL is more technical in nature, it is not difficult to see some overlap with Wood and Weigel's ladder when viewed in a broader sense. The TRL consists of nine levels, increasing in complexity, and while it is not applied in great depth in this study, it nevertheless helped to inform analysis of African space capabilities and activities. The next section will present the findings of the study, as well as the related discussion in terms of the frameworks and models used. However, additional analyses conducted as part of the study, including on the primary needs areas, history of Africa's space efforts, debates around the African Space Agency, space-related budgets, scientific output, and terrestrial infrastructure cannot be included here due to space limitations.

4. Findings and discussion

From the application of the IASE Matrix, it becomes clear that every country in Africa is involved in at least some capacity in the space sector, apart from merely being a user of space data. A very clear picture also emerges in terms of which countries are leaders in intra-African space engagement. This is where the concept of emerging space middle powers comes to the fore. To summarise, a middle power is a country that is neither particularly great nor small on the international stage in

terms of its power, capacity, or influence, and which tends to uphold and support the international order or status quo. Thus middle powers do not challenge but legitimise and stabilise that word order. Middle powers also strongly favour multilateral initiatives in order to build consensus and legitimacy. However, as mentioned, there is a distinction between traditional (developed) and emerging (developing) middle powers, in that emerging middle powers do not typically have fully consolidated democracies; tend to place more emphasis on economic matters, equity, and justice than on military or political ones; fall into the medium human development category; are regionally dominant and tend to be drivers of regional structures in which they are dominant; have a more neutral global posture; and are more active participants of international organisations dominated by the South [11].

Based on these features, it is possible to produce a framework to identify and classify the emerging space nations of Africa, based on the hypothesis that emerging middle powers of Africa will carry forth these principles in their space postures as well.

The expectations on a regional level following from the hypothesis here is that African space middle powers (i) place a strong emphasis on the socio-economic benefits of space technology as opposed to military or security objectives and (ii) strongly favour and drive regional and continental efforts to create space institutions and structures (including policy) in Africa while taking a leading or dominant position in these. Based on the IASE score assigned to each country, it is possible to identify the 'outliers' in intra-African space engagement. In order to arrive at a conception of African emerging space middle powers, the concept of power also needs to be accounted for. However, power can be defined in many different ways and is highly subjective. For the purposes here, a study and model used to score and rank countries developed by Y&R's BAV Group and the Wharton School of the University of Pennsylvania was utilised [17]. Once again, it should be emphasised that this is not being used to assign 'value' to countries but to gain a better understanding of emerging space middle powers in Africa.

Based on the findings presented in Table 2, nine African emerging space middle power candidates are identified according to their perceived international power and IASE score. These are Algeria, Egypt, Ghana, Kenya, Morocco, Nigeria, South Africa, Tanzania, and Tunisia. However, this does not yet reflect the international dimension of whether these countries actively support the international order or status quo in space, and thus the next matrix will delve into this dimension and complete the picture. Nevertheless, six categories of African states are revealed—those which are (i) more powerful and leaders in space engagement, (ii) those which are more powerful and well-engaged, (iii) those which are more powerful and not well-engaged, (iv) those which are less powerful and leaders in space engagement, (v) those which are less powerful and well-engaged, and (vi) those which are less powerful and not well-engaged.

Table 2. Six categories of African states based on power and space engagement

	IASE Above Mean	IASE Above Median	IASE Below Median
More Powerful	Algeria, Egypt, Ghana, Kenya, Morocco, Nigeria, South Africa, Tanzania, Tunisia		Angola
Less Powerful	Burkina Faso, Cameroon, Côte d'Ivoire, Ethiopia, Guinea-Bissau, Mali, Mauritius, Namibia, Niger, Republic of Congo, Senegal, Sudan, Uganda, Zambia, Zimbabwe	Benin, Libya, Madagas-car	Botswana, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Gabon, Guinea, Lesotho, Liberia, Malawi, Mauritania, Mozambique, Rwanda, São Tomé and Príncipe, Seychelles, Sierra Leone, Somalia, South Sudan, Swaziland, Gambia, Togo

Those states that are perceived as powerful and are leaders in their space engagement are the above-

mentioned candidates for Africa's emerging space middle powers—situated at the inner core of the continent's network of space-related organisations, relationships, and activities speaking to primary needs. In the outer core are those 15 states that perform very well in their space engagement, but are not considered to be very powerful, and thus in a sense these states are 'punching above their weight', showing a concerted effort to take part in the continent's space sector. At the periphery lie those states that are less powerful and received an IASE score below the median. These represent the untapped potential of the intra-African space arena, since these particular 27 states are at the lower end of the space engagement spectrum. Between the core and periphery lies the semiperiphery, with three less powerful states performing better than the median but not better than the mean in their IASE scores. Benin, Libya, and Madagascar can thus be argued to be rising African space actors in this regard.

Next, it is necessary to consider the dimension of Africa's relationships and participation in international space fora. In terms of such fora, UNCOPUOS is by far the most significant, As such, Africa's involvement in this body was analysed by way of the International Space Engagement (ISE) Matrix, which supplements the previously discussed Intra-African Space Engagement (IASE) Matrix by considering the international dimension of Africa's space engagement. UNCOPUOS is especially important here because middle powers are known by their global roles, not only their regional ones, and the international order in outer space (and other fields) is embodied by the UN. Moreover, since UNCOPUOS is the global governance forum for outer space, its activities are comprehensive and highly relevant to all basic needs. Apart from active participation in UNCOPUOS, another critical indicator of engagement in international space affairs is whether states have signed or ratified the five major space-related treaties. Doing so is not dependent on being an UNCOPUOS member, but African states in general have been slow to accede to these treaties. A total of 19 states have neither signed nor ratified any of the treaties. Only one, Morocco, has ratified all five treaties, while only four others have ratified all treaties apart from the Moon Agreement. Africa's international engagement in this regard is thus lacklustre, possibly again due to the misconception that it is to a large extent irrelevant for developing countries with other priorities. Findings are presented in Table 3.

Table 3. Twelve categories of African states based on economy and space engagement

	A) ISE Above Mean	B) ISE Above Median	C) ISE Below Median
1) High-Income	Seychelles		
2) Upper-Middle-Income	Algeria, Libya, South Africa		Botswana, Equatorial Guinea, Gabon, Mauritius, Namibia
3) Lower-Middle-Income	Egypt, Kenya, Morocco, Nigeria, Tunisia, Zambia	Cameroon, Ghana, Sudan	Angola, Cape Verde, Republic of the Congo, Côte d'Ivoire, Djibouti, Lesotho, Mauritania, São Tomé and Príncipe, Swaziland
4) Low-Income	Burkina Faso, Niger, Senegal	Benin, Burundi, Sierra Leone, Togo	Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Eritrea, Ethiopia, The Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Rwanda, Somalia, South Sudan, Tanzania, Uganda, Zimbabwe

By combining the factors of treaty signature or ratification, UNCOPUOS membership, active participation in UNCOPUOS, chairing or UNCOPUOS or its subcommittees, participating in UN-SPIDER, and hosting a Regional Centre for Space Science and Technology Education, it was possible to clearly identify those states that are strong proponents of the existing international order and its multilateral arrangements and

which, by virtue of their strong engagement, become African 'representatives' or mediators for the entire continent. As with the IASE Matrix, it is possible to identify the 'outliers' in international space engagement based on the ISE score assigned to each country. It thus becomes possible to identify leaders based on the international dimension of space engagement. The leaders in this regard are (in descending order) Nigeria, Algeria, Morocco, South Africa, Kenya, Tunisia, Egypt, Burkina Faso, Libya, Niger, Senegal, Zambia, and Seychelles. A small number of states do not score at or above the mean but nevertheless score at or above the median, which divides the continent between 21 more internationally engaged and 33 less internationally engaged states.

While the picture presented by the ISE (and IASE) scores do not necessarily provide an exhaustive account of all African engagement with space, a very clear trend emerges nevertheless, and again the purpose behind compiling these scores is not to 'value' states or their engagement but to illuminate the main patterns thereof. Similar to how the Intra-African Space Engagement Matrix was combined with the concept of power to narrow the emerging space middle power candidates, here, the economic dimension in terms of gross national income (GNI) per capita was be combined with the International Space Engagement Matrix. An argument regarding limited funds can be made to partially explain the absence within UNCOPUOS of Niger, Benin, Chad, Sierra Leone, and Senegal—all classified as low-income economies by the World Bank. While the exception of Burkina Faso does stand out in this regard, just as a less powerful state will have difficulty fulfilling the role of a middle power, so too will a low-income economy. This is again not a fixed rule but is a helpful heuristic device.

Based on these findings, 12 categories of African states can be identified (as represented in Table 3 above). These are defined by the level of the economy and the ISE score of all 54 states. Again, a core, periphery, and semi-periphery are apparent. In the core, a pattern emerges that shows that countries with high levels of international space engagement are spread out throughout all economic categories. Thus, a key finding is that other factors such as political will must be the primary drivers of national space engagement and cannot be discounted, while awareness and outreach efforts must continue. In this low-income category, while both Niger and Senegal score above the mean despite not being active UNCOPUOS members, the true outlier is Burkina Faso given its dedication in attending each UNCOPUOS session in the last 4 years (2015–2018). It can thus be argued that Burkina Faso has shown a high level of political will to drive a concerted effort to take part and cooperate in the space arena, although the factor of maintaining an embassy in Vienna does make it easier for Burkina Faso to attend UNCOPUOS meetings. Conversely, it could be argued that the upper-middle-income countries of Botswana, Equatorial Guinea, Gabon, and Namibia are underperformers since none of them have joined UNCOPUOS despite Namibia's attendance as observer, and Namibia also maintains an embassy in Vienna.

In the case of the ISE scores, the entire core category can thus be considered as emerging space middle power candidates, since it has been shown that space engagement does not depend on levels of economic development. Thus, the 13 high scoring states were be compared to the list of candidates from the IASE Matrix (combined with power perception) discussed earlier, to find the African emerging space middle powers (Table 4 depicts these per REC). In terms of the African RECs, all are represented by at least one emerging space middle power candidate, with the notable exception of ECCAS. However, ECCAS does have other outer core members. The core states in each of the RECs are thus the regional leaders and positioned to be the drivers and promoters of infusing space into African societies to assist meeting primary needs.

The result of this analysis reveals the emerging space middle powers, and thus the continental leaders to be Algeria, Egypt, Kenya, Morocco, Nigeria, South Africa, and Tunisia. These seven countries must play the main leadership role for Africa to meet its goals and targets set out in the AU's Agenda 2063 first 10-year implementation plan.

Table 4. Emerging space middle powers by regional economic community

	Emerging Space Middle Powers
Arab Maghreb Union (UMA)	**Algeria, Morocco**, **Tunisia**
Common Market for Eastern and Southern Africa (COMESA)	**Egypt, Kenya, Tunisia**
Community of Sahel–Saharan States (CEN–SAD)	**Egypt, Morocco, Nigeria, Kenya, Tunisia**
East African Community (EAC)	**Kenya**
Economic Community of Central African States (ECCAS)	*Cameroon, Republic of Congo*
Economic Community of West African States (ECOWAS)	**Nigeria**
Intergovernmental Authority on Development (IGAD)	**Kenya**
Southern African Development Community (SADC)	**South Africa**

Following this analysis, the adapted Space Technology Ladder discussed previously was applied per REC to identify the progress of major space technology achievements in Africa. The findings are presented below (Fig. 4–8; Note: since many African states are members of more than one REC, each was included only once to avoid duplication). Detailed analysis was performed in line with the frameworks discussed earlier (such as Harding's EMSA framework), as well an in-depth investigation into the space sector and satellites of each country (see [1]).

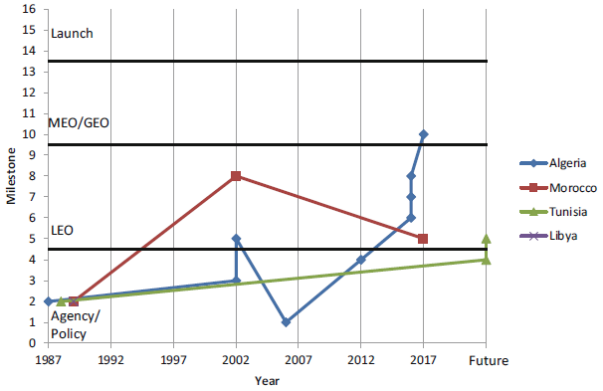

Fig. 4. Milestone timeline—Arab Maghreb Union

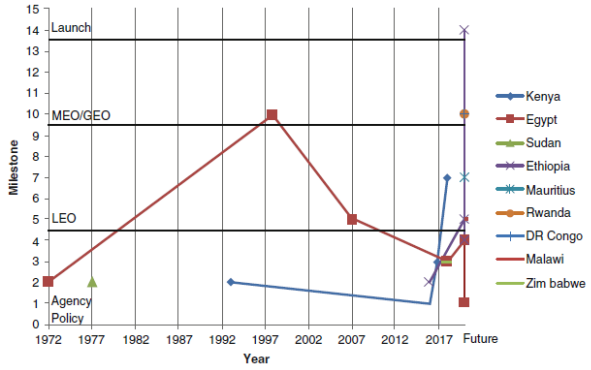

Fig. 5. Milestone timeline—Common Market for Eastern and Southern Africa (COMESA)

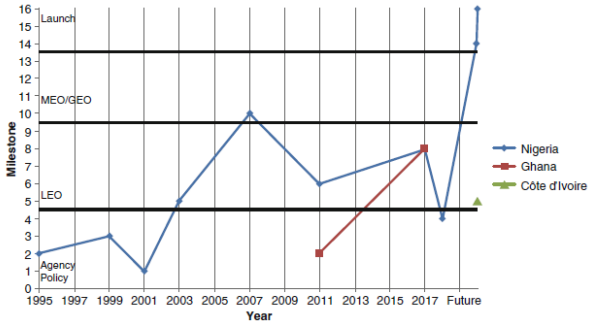

Fig. 6. Milestone timeline—Community of Sahel-Saharan States (CEN-SAD)

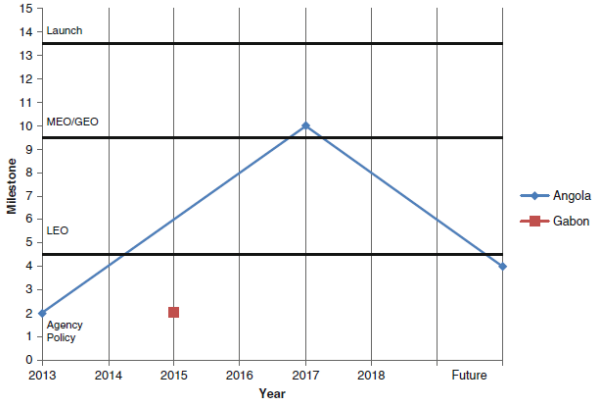

Fig. 7. Milestone timeline—Economic Community of Central African States (ECCAS)

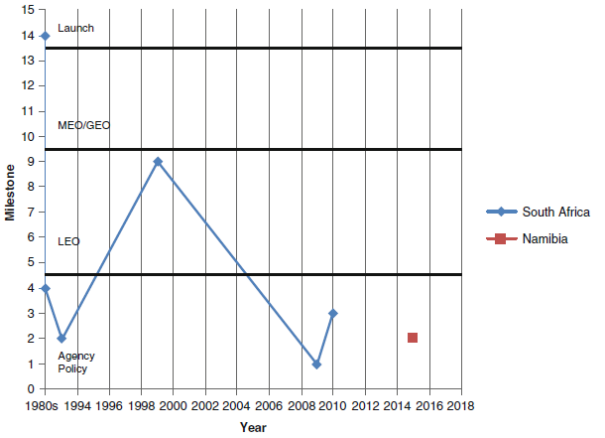

Fig. 8. Milestone timeline—Southern African Development Community (SADC)

5. Conclusions

The study aimed to complete the picture, presented in Fig. 3, of Africa's space growth poles by utilising the modified Space Technology Ladder, Harding's emerging space actor framework, and some basic concepts from the European Space Agency's Technology Readiness Level framework (such as reports of basic principles observed regarding upcoming satellites, concepts, and functions). Together with the analysis of African space engagement, these capability and infrastructure considerations now allow conclusions to be drawn regarding Africa's space growth poles and emerging space middle powers in the context of primary needs.

Strong upward trajectories in terms of milestone achievements are visible in a range of countries across the continent. The most prominent are Algeria, Egypt, Nigeria, Kenya, and South Africa and, to a lesser (but no less significant) extent, Angola, Ethiopia, Tunisia, Morocco, and Ghana, with others showing promise as well. Combined with an assessment of their status within the EMSA framework, it was possible to identify

Africa's space growth poles, as well as to provide an updated assessment of the continent's space sector. This was done by combining engagement in space and national space capabilities and identifying national trajectories and key focus areas based on the analysis above. The findings reinforce the sense of the rapid pace at which African states have been increasing their space-related capabilities and while Harding argued that South Africa was a second-tier EMSA in 2013, two more states can arguably be counted in that category today, with two more approaching that point through development of significant capabilities in terms of space technology.

Institutionally, African states have also been expanding their capabilities, with Zimbabwe a very recent example. This reflects the recognition among African leaders and decision-makers of the value and importance of space for societal development. The analysis, by way of the modified Space Technology Ladder, also made it possible to compare the approaches or pathways of countries in pursuing space capabilities. Egypt and Angola have, for instance, placed great emphasis on communication via their NileSat and AngoSat programmes—recently also joined by Algeria with its AlComSat-1. Morocco, on the other hand, has pursued high-resolution Earth observation for both developmental and military objectives, turning to foreign manufacturers to provide these sophisticated tools. Meanwhile, Kenya, Ghana, Mauritius and, in some cases, Morocco and South Africa have developed satellites and engineering skills via international initiatives such as the Birds programme, or the TUBSAT programme, or other collaborations such as ThinSat. This is often reflective of the initial efforts of countries to build up a cadre of space professionals and clearly demonstrates the democratisation and opening up of space to developing nations through the small satellite revolution. Algeria, Nigeria, and South Africa have also focused heavily on developing their domestic manufacturing capabilities, and in all three cases, this has been guided by a clear strategy, driven by a responsible space authority. Egypt is also joining in this effort via its new Space City development (and is also hosting AfSA), as is Tunisia via its Sfax Technopole project, and thus these states form the core of what was referred to above as the African Regional Space Regime Complex.

Via the frameworks utilised in this study, it is thus possible to identify comparable groups of countries based on their space sector initiatives. South Africa, Nigeria, and Algeria form the core, and Egypt and Tunisia are approaching the core, while Kenya, Morocco, Ghana, Angola, and Ethiopia are key rising space actors, with Gabon, Sudan, Libya, Mauritius, Rwanda, the Democratic Republic of the Congo, Malawi, Zimbabwe, Côte d'Ivoire, and Namibia undertaking establishment of their capabilities. This study has also reinforced the sense of overlap between the RECs, which serves to strengthen the need for continental coordination via AfSA, for example. However, it is also clear that this overlap is good for building the African Regional Space Regime Complex and reinforces the power of space to overcome divisions within the RECs, and thus across Africa.

Acknowledgements

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References

[1] A. Froehlich, A. Siebrits, Space Supporting Africa Volume 1: A Primary Needs Approach and Africa's Emerging Space Middle Powers, Springer, Cham, 2019.

[2] K. Gottschalk, Astronaissance: Communicating Astronomy & Space to the African Imagination, The Re-emergence of Astronomy in Africa: A Transdisciplinary Interface of Knowledge Systems Conference, Maropeng, South Africa, 2012, 10–11 September.

[3] African Union Commission, Regional Economic Communities (RECs), https://au.int/en/organs/recs (accessed 17.06.18).

[4]African Union Commission and New Zealand Crown, African Union Handbook 2018: A Guide for those working with and within the African Union, fifth ed., African Union Commission and Ministry of Foreign Affairs and Trade/Manatū Aorere, Addis Ababa, Ethiopia and Wellington, New Zealand, 2018, https://au.int/sites/default/files/pages/31829-file-african_union_handbook_2018_english-2.pdf (accessed 05.12.18).

[5] T. Aganaba-Jeanty, Precursor to an African Space Agency: Commentary on Dr. Peter Martinez 'Is There a Need for an African Space Agency?', Space Policy 29 (2013) 173.

[6] R.M. Achieng, Can We Speak of African Agency?: APRM and Africa's Agenda 2063, African Sociological Review 18 (2014) 54.

[7] African Union Commission, The Key Agenda 2063 Flagship Programmes Projects, https://au.int/sites/default/files/documents/33126-doc-04_the_key_agenda_2063_flagship.pdf (accessed 21.06.18).

[8] K. Smith, Contrived boundaries, kinship and Ubuntu: A (South) African view of 'the international', in A.B Tickner and D.L. Blaney (Eds.), Thinking

International Relations Differently, Routledge, London, 2012.
[9] R.M. Achieng, Can We Speak of African Agency?: APRM and Africa's Agenda 2063, African Sociological Review 18 (2014) 54.
[10] K. Smith, Reshaping International Relations: Theoretical Innovations from Africa, All Azimuth 7 (2018) 88.
[11] E. Jordaan, The Concept of a Middle Power in International Relations: Distinguishing Between Emerging and Traditional Middle Powers, Politikon 30 (2003) 165.
[12] United Nations, Sustainable Development Goals, https://sustainabledevelopment.un.org/?menu=1300 (accessed 06.12.2018).
[13] P. Martinez, Is There a Need for an African Space Agency?, Space Policy 28 (2012) 143.
[14] D. Wood, A. Weigel, Charting the Evolution of Satellite Programs in Developing Countries – The Space Technology Ladder, Space Policy 28 (2012).
[15] R.C. Harding, Space Policy in Developing Countries: The Search for Security and Development on the Final Frontier, Routledge, London, 2013.
[16] A.A. Abiodun, Trends in the Global Space Arena – Impact on Africa and Africa's Response, Space Policy 28 (2012) 285-288.
[17] U.S. News & World Report L.P., Power Rankings, 2018, https://www.usnews.com/news/best-countries/power-rankings (accessed 14.09.2018).

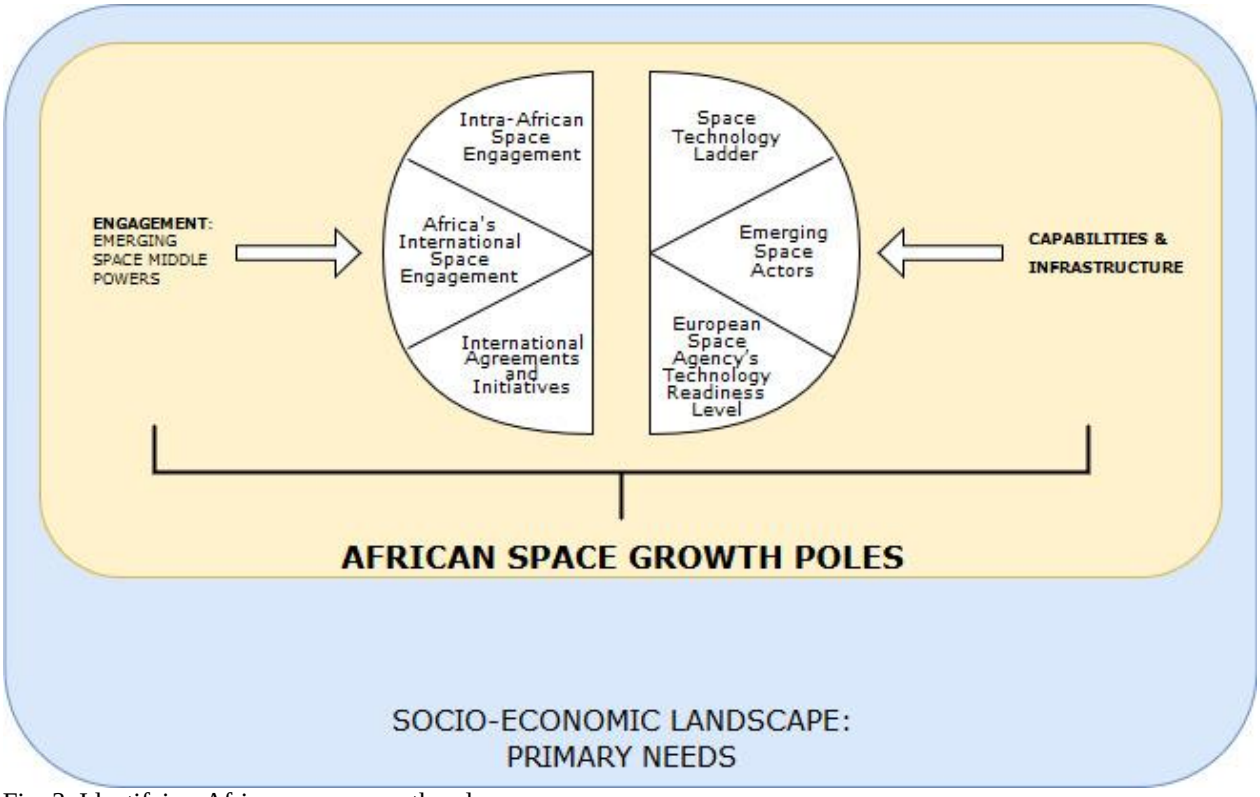

Fig. 3. Identifying African space growth poles